THE CLAIMS:

1. A sensing device for: sensing coded data disposed on a surface; and generating interaction data based on the sensed coded data, the interaction data being indicative of interaction of the sensing device with the surface; the sensing device comprising:

(a) an image sensor for capturing image information;

(b) at least one analog to digital converter for converting the captured image information into image data;

(c) an image processor for processing the image data to generate processed image data;

(d) a host processor for generating the interaction data based at least partially on the processed image data.

2. A sensing device according to claim 1, wherein the image sensor and the at least one analog to digital converter are integrated on a monolithic integrated circuit.

3. A sensing device according to claim 1, wherein the image sensor, the at least one analog to digital converter and the image processor are integrated on a monolithic integrated circuit.

4. A sensing device according to claim 1, further including a first framestore for storing frames of the image data.

5. A sensing device according to claim 4, wherein the image sensor and the at leat one analog to digital converter are integrated on a monolithic integrated circuit.

6. A sensing device according to claim 5, wherein the first framestore is integrated onto the monolithic integrated circuit.

7. A sensing device according to claim 4, wherein the image processor includes subsampling means for subsampling the image data to generate subsampled image data.

8. A sensing device according to claim 7, wherein the image processor is integrated on a monolithic integrated circuit, the monolithic integrated circuit including a first subsampled framestore for storing the subsampled image data based on image data from the first framestore.

9. A sensing device according to claim 4, further including a second framestore, the sensing device being configured such that the first and second framestores respectively store alternate frames of the image data associated with alternate frames of image information sensed by the image sensor.

10. A sensing device according to claim 9, wherein the first and second framestores are integrated on a monolithic integrated circuit.

11. A sensing device according to claim 9, further including a second subsampled framestore for storing subsampled image data based on image data from the second framestore.

12. A sensing device according to claim 11, wherein the first and second framestores and the first and second subsampled framestores are integrated on a monolithic integrated circuit.

13. A sensing device according to claim 7, wherein the image processor includes a low-pass filter for low-pass filtering the image data prior to subsampling it.

14. A sensing device according to claim 7, wherein the image processor includes range expansion means for range expanding the subsampled image data.

15. A sensing device according to claim 13, wherein the image processor includes range expansion means for range expanding the subsampled image data.

16. A sensing device according to claim 1, wherein the image processor includes a low-pass filter for filtering the image data.

17. A sensing device according to claim 1, wherein the image processor includes a range expansion circuit for range expanding the digital image data.

18. A sensing device according to claim 1, wherein the image sensor comprises an array of photodetecting circuits, each of the photodetecting circuits comprising:

a photodetector for generating a signal in response to incident light;

a storage node having first and second node terminals, the first node terminal being connected to the photodetector to receive the signal such that charge stored in the node changes during an integration period of the photodetecting circuit; and

an output circuit for generating an output signal during a read period of the photodetecting circuit, the output signal being at least partially based on a voltage at the first terminal;

the photodetecting circuit being configured to:

receive a reset signal;

integrate charge in the storage node during an integration period following receipt of the reset signal; and

receive a compensation signal at the second terminal of the storage node at least during the read period, the compensation signal increasing the voltage at the first terminal whilst the output circuit generates the output signal.

19. A sensing device according to claim 18, wherein the compensation signal is a logically negated version of the transfer signal.

20. A sensing device according to claim 1, the photodetector circuit being a CMOS circuit.

21. A sensing device according to claim 1, wherein at least one of the image processor and the host processor is disposed on a monolithic integrated circuit, the monolithic integrated circuit including:

timing circuitry for generating:

at least one internal timing signal, the image sensor being responsive to at least one of the internal timing signals to at least commence sensing of the image information; and

at least one external timing signal;

at least one external pin for supplying the at least one external timing signal to at least one peripheral device of the sensing device.

22. A sensing device according to claim 21, wherein the at least one internal timing signal includes a frame exposure signal.

23. A sensing device according to claim 21, wherein timing of at least one of the external timing signals is programmable relative to at least one of the internal timing signals.

24. A sensing device according to claim 23, wherein the timing is programmable by way of modifying a value stored in a register accessible by the timing circuitry.

25. A sensing device according to claim 21, wherein a duration of at least one of the external timing signals is programmable.

26. A sensing device according to any one of claims 21, wherein the at least one external signal includes a light source control signal.

27. A sensing device according to claim 26, wherein timing of the light source control signal is programmed to cause actuation of a light source prior to the internal timing signal causing the image sensor to commence sensing of the image data.

28. A sensing device according to claim 21, wherein the image processor includes a synchronous interface for outputting the image data serially to the host processor in reliance on a synchronising signal therefrom, and the image processor operates according to a system clock signal that is based on the synchronising signal.

29. A sensing device according to claim 28, wherein the image processor and the host processor are disposed on different monolithic integrated circuits.

30. A sensing device according to claim 1, wherein the image processor and the host processor are integrated on respective first and second monolithic integrated circuits, and the image processor is configured to make each of a series of frames of the image data available to the host processor, the image processor being configured to:

receive a first message from the host processor indicative of the host processor not requiring further access to the image data prior to a subsequent frame synchronisation signal;

in response to the first message, cause at least part of the first monolithic integrated circuit in which the image processor is integrated to enter a low power mode; and

in response to a frame synchronisation signal, cause the part of the first monolithic integrated circuit in the low power mode to exit the low power mode.

31. A sensing device according to claim 30, configured to generate the frame synchronisation signal.

32. A sensing device according to claim 30, wherein the part of the monolithic integrated circuit includes at least some circuitry associated with the image processor.

33. A sensing device according to claim 30, wherein the image processor is configured to process the image data in accordance with an image processing function prior to the host processor accessing it.

34. A sensing device according to claim 1, wherein the image processor and the host processor are disposed on respective first and second monolithic integrated circuits, the image processor being configured to:

receive, from the host processor, a request for access to a next available frame of image data from a framestore;

in the event the frame of image data is available, send a message to the host processor indicative of the image data's availability; and

in the event the frame of image data is not available, wait until it is available and then send a message to the host processor indicative of the image data's availability.

35. A sensing device according to claim 34, wherein the first monolithic integrated circuit includes the framestore.

36. A sensing device according to claim 34, further including at least one output pin for serially outputting data from the first monolithic integrated circuit in accordance with an external synchronising signal, the output data being based at least partially on the image data.

37. A sensing device according to claim 34, wherein the image sensor and the image processor operate asynchronously with respect to each other.

38. A sensing device according to claim 34, wherein the image processor is configured to:

receive a message from the host processor confirming that image data in the framestore is no longer required; and

in the event that new image data is received to be stored in the framestore prior to the message being received, discarding the new image data.

39. A sensing device according to claim 38, configured to, in the event that the new image data is discarded, record that a frame overrun has occurred.

40. A sensing device according to claim 38, being configured to, upon receipt of the message, set a flag in the image processor indicating that the framestore is ready to accept new image data.

41. A sensing device according to claim 1, wherein the image processor and the host processor are integrated on respective first and second monolithic integrated circuits, the first monolithic integrated circuit including:

at least one input pin for receiving command data from the host processor;

at least one output pin for transmitting the processed image data to the host processor in response to the command data.

42. A sensing device according to any one of claims 1, 34 or 41, wherein the coded data is indicative of a plurality of reference points, the host processor being configured to generate the interaction data by determining at least one of the reference points from the sensed coded data.

43. A sensing device according to claim 42, wherein the host processor is configured to determine a position of the sensing device relative to the coded data, based at least partially on the at least one determined reference point, the interaction data including the position.

44. A sensing device according to claim 43, wherein the interaction data includes movement data indicative of a plurality of the positions of the sensing device relative to the coded data over time.

45. A sensing device according to claim 1, the coded data including periodic elements, wherein the interaction data includes movement data indicative of a plurality of the positions of the sensing device relative to the coded data over time, the sensing device having generated the movement data on the basis of the sensing device's movement relative to at least one of the periodic elements.

46. A sensing device according to claim 45, further including a distance estimation means configured to estimate a distance of the sensing device from the at least one reference point or periodic element.

47. A sensing device according to claim 43, wherein the host processor is configured to resolve a more accurate position of the sensing device relative to the coded data than that indicated by the at least one reference point alone.

48. A sensing device according to claim 42, further including communications means for communicating the interaction data to a computer system

49. A sensing device according to claim 48, further including orientation sensing

means configured to sense an orientation of the sensing device relative to at least some of the coded data.

50. A sensing device according to claim 49, wherein the communications means is configured to communicate orientation data to the computer system, the orientation data being indicative of the orientation.

51. A sensing device according to claim 48, further including timer means configured to generate a time reference as the sensing device is moved relative to the coded data.

52. A sensing device according to claim 51, wherein the communications means is configured to communicate time reference data to the computer sytem, the time reference data being indicative of the time reference of the interaction data as generated by the timer means.

53. A sensing device according to claim 48, wherein the communications means is a wireless communications means.

54. A sensing device according to claim 48, further including a force sensing means configured to sense a force applied to the surface by the sensing device.

55. A sensing device according to claim 54, wherein the communications means is configured to communicate force data to the computer system, the force data being indicative of the force.

56. A sensing device according to claim 54, further including a stroke detection means configured to detect, by way of the force, when the sensing device is applied to the surface and removed from the surface, thereby to identify the duration of a stroke.

57. A sensing device according to claims 54, further including a marking nib for marking the surface.

58. A sensing device according to claim 53, wherein the sensing device is in the form of a stylus or pen.

59. A sensing device according to claim 58, wherein the coded data is printed using infrared ink, the sensing device being responsive in the infrared spectrum.

60. A sensing device according to claim 52, wherein the coded data includes a plurality of tags, each of which is indicative of: an identity of a region within which the tag lies; and of a reference point of the region; the region being associated with the surface, the reference point being indicative of the position of the tag within the region.

61. A sensing device according to claim 1, wherein at least some of the coded data is indicative of an identity of a region within which the coded data lies.

62. A sensing device according to claim 61, wherein the coded data includes a plurality of tags, each of the tags being indicative of an identity of a region within which the

tag lies.

63. A sensing device according to claim 42, the coded data being disposed on the surface in accordance with at least one layout, the layout having at least order n rotational symmetry, where n is at least two, the layout including n identical sub-layouts rotated 1/n revolutions apart about a centre of rotational symmetry of the layout, the coded data disposed in accordance with each sub-layout including rotation-indicating data that distinguishes the rotation of that sub-layout from the rotation of at least one other sub-layout within the layout, and wherein the processor is configured to determine the rotation-indicating data of at least one of the sub-layouts, and to decode the coded data based at least partially on the determined rotation-indicating data.

64. A sensing device according to claim 42, the coded data being disposed on or in a substrate in accordance with at least one layout, the layout having at least order n rotational symmetry, where n is at least two, the layout encoding orientation-indicating data comprising a sequence of n symbols, each symbol being positioned at a respective one of n locations arranged about a centre of rotational symmetry of the layout, thereby such that decoding the symbol at each of the n orientations of the layout produces n representations of the orientation-indicating data, each representation comprising a different cyclic shift of the orientation-indicating data and being indicative of the degree of rotation of the layout, the host processing means being configured to determine a relative rotation of the coded data by determining one of the representations of the orientation-indicating data.

65. A sensing device according to claim 42, wherein the surface is part of packaging or a label associated with a product item, or is part of the product item itself, and the coded data is indicative of a product identity of the product item.

66. A sensing device according to claim 65, wherein the coded data includes a plurality of coded data portions, each of the coded data portions being indicative of the product identity.

67. A sensing device according to claim 65, wherein the coded data encodes an EPC associated with the product item, and the interaction data includes the EPC.

68. A sensing device for: sensing coded data disposed on a surface; and generating interaction data based on the sensed coded data, the interaction data being indicative of interaction of the sensing device with the surface; the sensing device comprising:

(a) a monolithic integrated circuit, comprising:

(i) an image sensor for capturing image information;

(ii) at least one analog to digital converter for converting the captured image information into image data;

(iii) a framestore for storing the image data; and

(b) a host processor for generating the interaction data based at least partially on the image data.

69. A sensing device according to claim 68, further including an image processor for processing the image data to generate processed image data, the host processor generating the interaction data based at least partially on the processed image data.

70. A sensing device according to claim 69, wherein the image processor is integrated on the monolithic integrated circuit.

71. A sensing device according to claim 69, wherein the image processor includes subsampling means for subsampling the image data from the first framestore to generate subsampled image data.

72. A sensing device according to claim 71, further including a first subsampled framestore for storing the subsampled image data based on image data from the first framestore.

73. A sensing device according to claim 72, wherein the first subsampled framestore is integrated on the monolithic integrated circuit.

74. A sensing device according to claim 68, further including a second framestore, the sensing device being configured such that the first and second framestores respectively store alternate frames of the image data associated with alternate frames of image information sensed by the image sensor.

75. A sensing device according to claim 74, wherein the second framestore is integrated on the monolithic integrated circuit.

76. A sensing device according to claim 74, further including first and second subsampled framestores, wherein the first and second subsampled framestores store subsampled image data based on image data from the first and second framestores respectively.

77. A sensing device according to claim 76, wherein the first and second subsampled framestores are integrated on the monolithic integrated circuit.

78. A sensing device according to claim 69, wherein the image processor includes a low-pass filter for low-pass filtering the image data.

79. A sensing device according to claim 69, wherein the image processor includes range expansion means for range expanding the image data.

80. A sensing device according to claim 68, wherein the host processor is configured to low-pass filter the image data.

81. A sensing device according to claim 68, wherein the host processor is configured to range expand the image data.

82. A sensing device according to claim 68, wherein the image sensor comprises an array of photodetecting circuits, each of the photodetecting circuits comprising:

a photodetector for generating a signal in response to incident light;

a storage node having first and second node terminals, the first node terminal being connected to the photodetector to receive the signal such that charge stored in the node changes during an integration period of the photodetecting circuit; and

an output circuit for generating an output signal during a read period of the photodetecting circuit, the output signal being at least partially based on a voltage at the first terminal;

the photodetecting circuit being configured to:

receive a reset signal;

integrate charge in the storage node during an integration period following receipt of the reset signal; and

receive a compensation signal at the second terminal of the storage node at least during the read period, the compensation signal increasing the voltage at the first terminal whilst the output circuit generates the output signal.

83. A sensing device according to claim 82, wherein the compensation signal is a logically negated version of the transfer signal.

84. A sensing device according to claim 82, the photodetector circuit being a CMOS circuit.

85. A sensing device according to claim 68, the monolithic integrated circuit including:

timing circuitry for generating:

at least one internal timing signal, the image sensor being responsive to at least one of the internal timing signals to at least commence sensing of the image information; and

at least one external timing signal;

at least one external pin for supplying the at least one external timing signal to at least one peripheral device of the sensing device.

86. A sensing device according to claim 85, wherein the at least one internal timing signal includes a frame exposure signal.

87. A sensing device according to claim 85, wherein timing of at least one of the external timing signals is programmable relative to at least one of the internal timing signals.

88. A sensing device according to claim 87, wherein the timing is programmable by way of modifying a value stored in a register accessible by the timing circuitry.

89. A sensing device according to claim 85, wherein a duration of at least one of the external timing signals is programmable.

90. A sensing device according to any one of claims 85, wherein the at least one external signal includes a light source control signal.

91. A sensing device according to claim 90, wherein timing of the light source control signal is programmed to cause actuation of a light source prior to the internal timing signal causing the image sensor to commence sensing of the image data.

92. A sensing device according to claim 85, wherein the image processor includes a synchronous interface for outputting the image data serially to the host processor in reliance on a synchronising signal therefrom, and the image processor operates according to a system clock signal that is based on the synchronising signal.

93. A sensing device according to claim 92, wherein the image processor and the host processor are disposed on different monolithic integrated circuits.

94. A sensing device according to claim 68, wherein the image processor and the host processor are integrated on respective first and second monolithic integrated circuits, and the image processor is configured to make each of a series of frames of the image data available to the host processor, the image processor being configured to:

receive a first message from the host processor indicative of the host processor not requiring further access to the image data prior to a subsequent frame synchronisation signal;

in response to the first message, cause at least part of the first monolithic integrated circuit is disposed to enter a low power mode; and

in response to a frame synchronisation signal, cause the part of the first monolithic integrated circuit in the low power mode to exit the low power mode.

95. A sensing device according to claim 94, configured to generate the frame synchronisation signal.

96. A sensing device according to claim 94, wherein the part of the monolithic integrated circuit includes at least some circuitry associated with the image processor.

97. A sensing device according to claim 94, wherein the image processor is configured to process the image data in accordance with an image processing function prior to the host processor accessing it.

98. A sensing device according to claim 94, wherein the image processor and the host processor are integrated on respective first and second monolithic integrated circuits, the image processor being configured to:

receive, from the host processor, a request for access to a next available frame of image data from a framestore;

in the event the frame of image data is available, send a message to the host processor indicative of the image data's availability; and

in the event the frame of image data is not available, wait until it is available and then send a message to the host processor indicative of the image data's availability.

99. A sensing device according to claim 98, further including at least one output pin for serially outputting data from the first monolithic integrated circuit in accordance with an external synchronising signal, the output data being based at least partially on the image data.

100. A sensing device according to claim 98, wherein the image sensor and the image processor operate asynchronously with respect to each other.

101. A sensing device according to claim 100, wherein the image processor is configured to:

receive a message from the host processor confirming that image data in the framestore is no longer required; and

in the event that new image data is received to be stored in the framestore prior to the message being received, discarding the new image data.

102. A sensing device according to claim 101, configured to, in the event that the new image data is discarded, record that a frame overrun has occurred.

103. A sensing device according to claim 101, being configured to, upon receipt of the message, set a flag in the image processor indicating that the framestore is ready to accept new image data.

104. A sensing device according to claim 68, wherein the image processor and the host processor are disposed on respective first and second monolithic integrated circuits, the first monolithic integrated circuit including:

at least one input pin for receiving command data from the host processor;

at least one output pin for transmitting the processed image data to the host processor in response to the command data.

105. A sensing device according to any one of claims 68, 98 or 104, wherein the coded data is indicative of a plurality of reference points, the host processor being configured to generate the interaction data by determining at least one of the reference points from the sensed coded data.

106. A sensing device according to claim 105, wherein the host processor is configured to determine a position of the sensing device relative to the coded data, based at least partially on the at least one determined reference point, the interaction data including the position.

107. A sensing device according to claim 106, wherein the interaction data includes movement data indicative of a plurality of the positions of the sensing device relative to the coded data over time.

108. A sensing device according to claim 68, the coded data including periodic elements, wherein the interaction data includes movement data indicative of a plurality of the positions of the sensing device relative to the coded data over time, the sensing device having generated the movement data on the basis of the sensing device's movement relative to at least one of the periodic elements.

109. A sensing device according to claim 108, further including a distance estimation means configured to estimate a distance of the sensing device from the at least one reference point or periodic element.

110. A sensing device according to claim 106, wherein the host processor is configured to resolve a more accurate position of the sensing device relative to the coded data than that indicated by the at least one reference point alone.

111. A sensing device according to claim 106, further including communications means for communicating the interaction data to a computer system

112. A sensing device according to claim 111, further including orientation sensing means configured to sense an orientation of the sensing device relative to at least some of the coded data.

113. A sensing device according to claim 112, wherein the communications means is configured to communicate orientation data to the computer system, the orientation data being indicative of the orientation.

114. A sensing device according to claim 107, further including timer means configured to generate a time reference as the sensing device is moved relative to the coded data.

115. A sensing device according to claim 114, wherein the communications means is configured to communicate time reference data to the computer sytem, the time reference data being indicative of the time reference of the interaction data as generated by the timer means.

116. A sensing device according to claim 111, wherein the communications means is a wireless communications means.

117. A sensing device according to claim 111, further including a force sensing means configured to sense a force applied to the surface by the sensing device.

118. A sensing device according to claim 117, wherein the communications means is configured to communicate force data to the computer system, the force data being indicative of the force.

119. A sensing device according to claim 117, further including a stroke detection means configured to detect, by way of the force, when the sensing device is applied to the surface and removed from the surface, thereby to identify the duration of a stroke.

120. A sensing device according to claims 117, further including a marking nib for marking the surface.

121. A sensing device according to claim 116, wherein the sensing device is in the form of a stylus or pen.

122. A sensing device according to claim 121, wherein the coded data is printed using infrared ink, the sensing device being responsive in the infrared spectrum.

123. A sensing device according to claim 39, wherein the coded data includes a plurality of tags, each of which is indicative of: an identity of a region within which the tag lies; and of a reference point of the region; the region being associated with the surface, the reference point being indicative of the position of the tag within the region.

124. A sensing device according to claim 68, wherein at least some of the coded data is indicative of an identity of a region within which the coded data lies.

125. A sensing device according to claim 124, wherein the coded data includes a plurality of tags, each of the tags being indicative of an identity of a region within which the tag lies.

126. A sensing device according to claim 105, the coded data being disposed on the surface in accordance with at least one layout, the layout having at least order n rotational symmetry, where n is at least two, the layout including n identical sub-layouts rotated 1/n revolutions apart about a centre of rotational symmetry of the layout, the coded data disposed in accordance with each sub-layout including rotation-indicating data that distinguishes the rotation of that sub-layout from the rotation of at least one other sub-layout within the layout, and wherein the processor is configured to determine the rotation-indicating data of at least one of the sub-layouts, and to decode the coded data based at least partially on the determined rotation-indicating data.

127. A sensing device according to claim 105, the coded data being disposed on or in a substrate in accordance with at least one layout, the layout having at least order n rotational symmetry, where n is at least two, the layout encoding orientation-indicating data comprising a sequence of n symbols, each symbol being positioned at a respective one of n locations arranged about a centre of rotational symmetry of the layout, thereby such that decoding the symbol at each of the n orientations of the layout produces n representations of the orientation-indicating data, each representation comprising a different cyclic shift of the orientation-indicating data and being indicative of the degree of rotation of the layout, the host processing means being configured to determine a relative rotation of the coded data by determining one of the representations of the orientation-indicating data.

128. A sensing device according to claim 105, wherein the surface is part of packaging or a label associated with a product item, or is part of the product item itself, and the coded data is indicative of a product identity of the product item.

129. A sensing device according to claim 128, wherein the coded data includes a plurality of coded data portions, each of the coded data portions being indicative of the product identity.

130. A sensing device according to claim 128, wherein the coded data encodes an EPC associated with the product item, and the interaction data includes the EPC.